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STATION PAPER NO. 72
JUNE 1959

DIRECT SEEDING and PLANTING of Balsam Fir in Northern Wisconsin

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LAKE STATES FOREST EXPERIMENT STATION
FOREST SERVICE
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Direct Seeding and Planting of Balsam Fir in Northern Wisconsin

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Introduction

Balsam fir (Abies balsamea) is without question the most aggressive conifer in the Lake States in becoming established on the better classes of forest soils with good moisture relations. It is tolerant, has the ability to germinate well on duff and humus of broadleaf species, and produces seed abundantly at an early age (Roe 1950). It is converting a considerable acreage of the aspen-birch type (Stoeckeler 1948), where it appears typically as an understory species. Under good growing conditions it may have a mean annual increment of ½ cord per acre per year in a 60-year rotation (Gevorkiantz and Olsen 1950). Individual trees in pole stands on good sites may grow as much as 3 inches in a 10-year period (Day 1954).

Forest managers are interested in balsam fir because it establishes itself readily, is being used extensively in the sulphite pulp industry, and is a major substitute for the more costly white and black spruces. Both of the latter species are in short supply in the Lake States. Therefore, methods of artifically establishing balsam fir may warrant consideration by forest managers.

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[1] Maintained at St. Paul 1, Minn., in cooperation with the University of Minnesota.

Credit is due to L. B. Burkett, George Frisbie, and Richard W. Smith of the Forest Service for aid in selection of some sites and their ground preparation, and to Carl Arbogast, Jr., M. L. Heinselman, and H. C. Bell of the Lake States Forest Experiment Station for assistance in field counts.

Also, increasing interest is being shown in balsam fir by Christmas tree growers because of the good market value of the species, its high needle retention, its symmetry and compactness, and its favorable response to shearing and pruning.

Because of the aggressiveness of balsam fir in natural seeding in sites occupied by aspen, paper birch, and brush, artificial direct seeding would seem to have some promise.

For many years, direct seeding in the field has held the interest of foresters not only in the Lake States, but also in other regions. To date, the results in the Lake States have not been encouraging. There have been many more failures than successes. However, because of the short cut that direct seeding offers, eliminating the time and expense of raising and planting seedlings, it is an attractive field for research.

To date, very little research has been done in the Lake States on seeding and planting of balsam fir; however, a number of field trials have been made in northern Wisconsin. The results of these trials are presented in this paper. Each test is dealt with separately because they were conducted under varying conditions and direct comparison or summation of data is not possible. The Summary. however, draws the results together and presents overall conclusions.

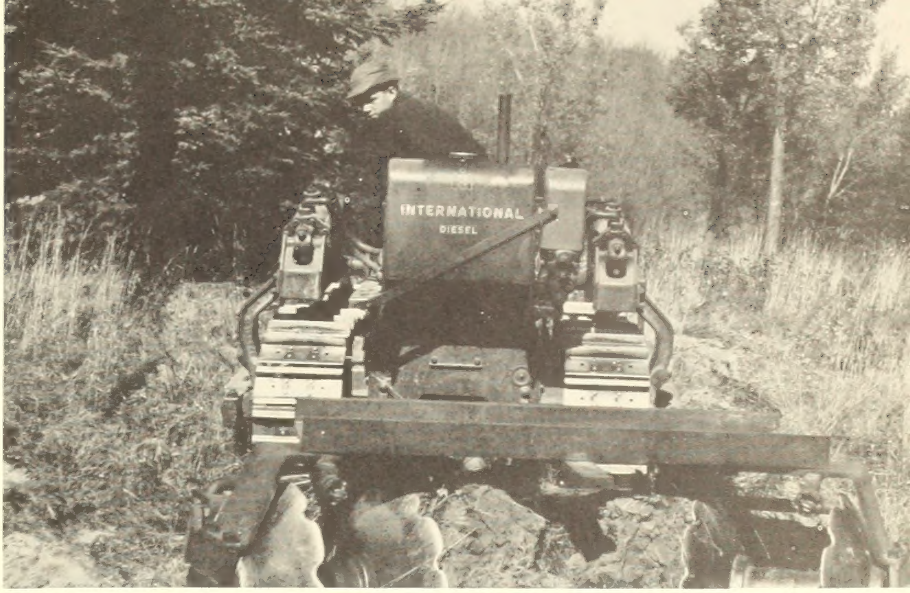
Trials on aspen sites

In the spring of 1948, a tract of about 10 acres of thinly stocked aspen from 1 to 8 inches in diameter near Alvin in northern Wisconsin, was prepared for testing several methods of converting to balsam fir. Most of the aspen trees, about 50 per acre, were in the 2- to 6-inch-diameter range.

The soil ranged from a fine to a very fine sandy loam and had a silt-plus-clay content of 40 to 45 percent. A rather impermeable hardpan of 6- to 8-inch thickness lay at a depth of 6 to 12 inches below the surface. This resulted in poor drainage in swales and flats. The tract was generally slightly undulating. It was originally hardwood, but was logged over 30 years ago, and then burned repeatedly.

A rather open portion of the area, comprising 3.3 acres, was heavily cross-disked, leaving about 3 to 5 square feet of residual basal area of aspen per acre. A nearby part of the tract (6.6 acres) had a stand of sapling aspen and paper birch with a density of 15 to 20 square feet of basal area per acre. This was disked in north-south strips 6 feet

Figure 1.--Disking in an open area is a means of ground preparation for seeding or planting.



wide at intervals of around 13 to 14 feet on center (fig. 1). These strips, which were gone over twice with the disk, were thus shaded by aspen and birch strips, providing a contrast with the open cross-disked area.

Part of each of the disked areas was seeded to balsam fir and part hand-planted to nursery-grown transplants of balsam fir and white spruce in the spring of 1948. There were no replications. A supplementary study to test three methods of covering the seed was installed on the disked strips.

Direct Seeding Trials

In the seeding tests it was not feasible to use counted seed or absolutely uniform numbers of spots per acre. The seed rates per acre, using moist stratified seed that ran 33,600 seeds per pound, were as follows: Seed not covered, open areas, 1.08 pounds; seed not covered, shade, 0.61 pound; seed covered, open areas, 0.67 pound; seed covered, shade, 0.74 pound.

Seeding was done about a week after disking by dropping pinches of approximately 27 seeds at intervals of about 4 feet on loose soil. By estimate, 95 percent of the seed fell on mineral soil and 5 percent on rotten wood chewed up by the disk. About half of the seed spots were covered--by hand in the open area and with a scrape of the foot for those in the shade. Seed spots averaged 1,086 per acre in the open. In the shade the average number of spots per mile of disked strip was 1,336, or around 840 per acre.

In the first season, rainfall was favorable, and the initial stand in both areas was fairly good. Counts made on milacre sample areas at the end of the first year (table 1) revealed an initial average stand in open and shaded areas respectively of 1,610 and 2,330 trees per acre, with 39 and 51 percent of the milacres stocked. By the end of the eleventh year, the stand in the open had been reduced to only 40 trees per acre, while under aspen cover it was still 755 trees per acre of disking. Thus, shade proved beneficial to the balsam fir seeding both initially and over the 11-year period. However, the increased stocking which resulted from shading was, in part, offset by reduced height growth. After 11 years, the trees in the open averaged 1.8 feet while under aspen they averaged 1.1 feet.

The advantage of seed covering was not definite. After 11 years a greater percent of quadrats in the shade where the seed had been covered were stocked, but in the open the quadrats with seed left uncovered did the best.

In a supplementary test, brush dragging, used as a rapid method of covering seed, was compared with the foot-covering methods. Brush dragging was done by pulling a freshly cut 4-inch-diameter aspen, butt first, down the disked strip immediately after seeding. It was thought that this would do a fairly successful job of covering the seed with a thin layer of soil. Covering by foot was done by the man doing the seeding. He dragged a light covering of soil over the seed with the side of his shoe and firmed it by stepping lightly on the seed spot.

The results (table 2) indicate that brush dragging resulted in a poorer stand than leaving the seed uncovered, or covering it by foot. Furthermore, seed covered by foot appeared to germinate slower than uncovered seed, judging by the lower percent of stand reduction from the first to the second year.

The adverse effect of brush dragging on stand per milacre was further verified in another experiment on this same area in a test involving 3,630 lineal feet of disked strip with about half of it dragged and half left undragged. The average stocking per milacre of disked strip was 3.42 and 6.26 seedlings respectively for dragged and untreated areas. This represents a 45-percent reduction in stand by brush dragging.

The adverse results by brush dragging are attributed to too deep a coverage of some of the seed and a tendency to drag seed from good positions of microsite (properly drained) into the very lowest areas where the seed subsequently was buried too deeply by soil washing and the seedlings were later matted down to some extent by leaf fall.

Table 1.--Trees per disked[1] acre and quadrat stocking of balsam fir on aspen land as affected by seed covering and overstory

Seed covering and overstory	Number of trees after:			Percent of quadrats stocked after:		
	1 year	2 years	11 years	1 year	2 years	11 years
Seeds not covered:						
In open	1,520	160	80	50	8	8
In shade	2,480	940	570	59	37	25
Seed covered:						
In open	1,700	360	0	28	12	0
In shade	2,180	1,430	940	44	44	34
Average:						
In open	1,610	260	40	39	10	4
In shade	2,330	930	755	51	40	30

[1] Trees per acre are calculated on the basis of area disked. To calculate trees per gross area under partial shade reduce the values in the table by 50 percent. Basis: 50 milacres in each covering method in the open and 100 milacres in each covering method in shade, or a total of 300 milacres.

Table 2.--Balsam fir trees per milacre of sample on disked strips in aspen, three methods of seed covering [1]

Method of seed covering	Number of trees after:		
	1 year	2 years	11 years
By foot	2.18	1.60	0.94
Brush-dragged	1.61	.99	.23
Not covered	2.48	1.35	.57

[1] Of disked strip only. The stand per lineal mile of disked strip can be computed by multiplying all values per milacre by 420. Basis: 100 milacres in each class of seed coverage.

Planting Results

Planting was done on open and shaded areas with the same ground preparation previously described for direct seeding. The test included 2-2 balsam fir and 2-3 white spruce (table 3). White spruce is the usual species chosen for reforestation of such sites and hence was planted for comparison purposes.

Table 3.--Specifications of nursery stock used

(Inches)

Age class and species	Length			Caliper at root collar
	Top	Root	Total	
2-2 balsam fir	5.7	10.1	15.8	0.15
2-3 white spruce	6.9	11.2	18.1	.21

Initially, the balsam fir planting showed better survival and height growth in the shade than in the open (table 4). After 11 years, however, this trend has reversed. The open-grown trees now show much better height growth than do the shade-grown trees, and survival is the same for both.

Comparing the spruce and balsam plantings, the spruce has shown better survival. Height growth is about equal to that of the open-grown balsam.

Comparison of Costs and Results In Planting Versus Seeding

Costs of seeding and planting were computed in terms of man-hours required per acre and per 1,000 spots on trees planted or spots seeded on the 10-acre experimental block (table 5). The 22 to 32 man-hours used per 1,000 trees planted is far greater than the labor requirement for seeding when the comparison is based on the number of trees planted or spots seeded. However, when the relative success of the planting and seeding is evaluated in terms of cost per surviving tree or per milacre occupied at the end of the 11th year, the results give a surviving-tree or spot cost as indicated on page 9.

Table 4.--Survival and growth of planted balsam fir and white spruce as affected by a thin cover of aspen

Years in field	2-2 balsam fir[1]				2-3 white spruce[2]			
	In the shade		In the open		In the shade		In the open	
(Number)	Survival	Height	Survival	Height	Survival	Height	Survival	Height
	Percent	Feet	Percent	Feet	Percent	Feet	Percent	Feet
1	98	0.3	99	0.4	99	0.6	96	0.6
2	98	.4	88	.4	98	.6	98	.6
3	96	.7	78	.4	96	1.0	98	1.0
4	96	1.6	76	.8	96	1.7	94	1.5
6	90	1.9	74	1.5	90	2.6	90	2.6
11	58	2.2	58	5.0	78	4.6	62	4.8

[1] Basis: 975 balsam fir in the shade, and 2,143 in the open.

[2] Basis: 900 white spruce in the shade, and 2,150 in the open.

Table 5.--Man-hours required for planting and seeding and estimated costs

Operation	Spots seeded or seedlings planted per acre	Time required for seeding or planting		Approximate cost per 1,000 trees or spots
		Per acre	Per 1,000 spots or plants	
	Number	Man-hours		Dollars
Planting 2-2 balsam fir in the open	969	22.5	23.2	37.20
Planting 2-3 white spruce in the open	1,000	22.2	22.2	36.00
Planting 2-2 balsam fir in the shade	1,178	26.6	22.6	36.60
Planting 2-3 white spruce in the shade	1,272	40.2	31.6	45.60
Direct seeded balsam fir in the open; not covered	1,342	1.1	.8	9.80
Direct seeded balsam fir in the open; hand covered	832	5.0	6.0	15.00
Direct seeded balsam fir in the shade; not covered	586	4.7	.8	9.80
Direct seeded balsam fir in the shade; covered by foot	704	1.4	2.0	11.00
Direct seeded balsam fir in the shade; brush dragged	636	1.3	2.0	11.00

Species	Cost per surviving tree or occupied spot after 11 years (cents)
2-3 white spruce	5.8
2-2 balsam fir	6.4
Balsam seeding in the open; seed not covered	12.2
Balsam seeding in the open; seed covered by hand	(1/)
Balsam seeding in the shade; seed not covered	3.9
Balsam seeding in the shade; seed covered by foot	3.2
Balsam seeding in the shade; brush dragged	9.2

1/ No survival.

On the survival basis, the balsam seeding in the open tracts was twice as expensive as use of transplants. The seeding under shade between the strips of aspen was quite competitive in cost with balsam transplants and is in the range of 3 to 4 cents per stocked milacre in the more successful methods. The advantage for the direct seeding would narrow if one assumed machine planting had been used.

In the evaluation it was assumed that around 3,000 seed spots could be placed in each acre of disked strip in order to have about 900 stocked milacres by the end of the 11th year. It is problematical whether that many good, bare, mineral-soil seed spot areas could be found per acre unless disked strips were placed closer together, or a narrower disk used, so as to still retain the apparently necessary overstory of about 20 to 25 square feet of basal area of aspen saplings and poles.

Considering the risks involved in seeding, planting appears to have been the most economical method for regenerating the tract. The high intrinsic value of spruce for sulphite pulping and its higher pulp yield make the planting of spruce much preferred.

Trials on northern hardwood sites

Balsam fir is frequently found as a component on northern hardwood stands where it often reaches a state of optimum development. Hence a number of trial seedings and plantings were made on understocked or former hardwood sites.

Direct Seeding

Effect of Cover and Microsite on a Seeding in Furrows

In the spring of 1949, a direct seeding was made on a fairly heavy loam soil. The area of about 2 acres on the Argonne District, Nicolet National Forest, had five rather distinct situations of cover, drainage, and soil. Seed was sown in 4-inch-deep furrows made with a planting plow the previous fall.

Seeding was done on May 7, 1949, by hand, using seed that had been stratified in moist sand for 7 weeks at around 46° F. It was covered with soil after being placed in a shallow scratch made with a flat iron bar. At time of planting the soil was amply moist, and more rains fell shortly thereafter.

In each of the five site conditions, 20 screened and 20 unscreened spots were seeded with 20 seeds each. All told, 4,000 counted seeds were used in the portion of the area sampled in repeat counts.

None of the areas had good survival after 2 years in spite of screening and regardless of cover condition. Those with thin hardwood or aspen cover had a better stand than those in the open or in depressed poorly drained areas. The second-year tree percent averaged 0.75 for the screened spots and only 0.25 for the unscreened.

When evaluated in terms of seed spots occupied at the end of the second season, the results are likewise poor. The best stand--that under a light hardwood cover and protected by screens--had only 25 percent of the spots stocked with 1 or more seedlings. Screening improved the catch on all sites by 5 to 10 percent.

The almost complete failure by the end of the second year is attributed to the competition created by sod, particularly quack grass and bluegrass, taking over the furrow bottoms where the seed spots were located.

Effect of Cover Crops on Balsam Fir Seeded in the Open

In the spring of 1950, direct seeding of balsam fir was tried in a heavily sodded flat of loam soil in an opening of about 40 acres formerly occupied by northern hardwoods. This area, on the Argonne Experimental Forest, was considered somewhat of a problem because of late spring frosts and conditions favorable for a heavy rodent population. The area was thoroughly prepared by cross-disking on August 23, 1949. Shortly thereafter, two 1/10-acre plots were seeded, one to rye and one to red clover. No cover crops were used on a third plot. It was surmised that the cover crop might provide some beneficial shade to the tender balsam seedlings and also give protection against late spring frosts.

The following spring 200 spots in each 1/10-acre plot were seeded to balsam fir, with 20 seeds per spot. Half of the spots were screened and half were left unscreened. In each plot there were 4,000 counted seeds, or a total of 12,000 in the trial.

The results of this test were certainly not encouraging. Although the first-year stand showed an advantage due to both screening and the use of cover crops, it was far from satisfactory under the best of these treatments. At the end of nine growing seasons, all treatments were a complete failure with less than 2.0 percent of the spots occupied even on screened areas. This emphasizes the fact that even with screening, open flats of this type are a difficult seeding chance with poor prospects of success.

Seeding in Sodded Understocked Second-Growth Northern Hardwoods

On May 6, 1948, an area of understocked northern hardwoods on the Argonne Experimental Forest in northeastern Wisconsin with about 5 square feet of basal area per acre was disked to expose about 60 percent mineral soil. The area had been in rather heavy-to-medium sod, which was densest in the open places. The soil was a silt loam to loam of good moisture relations and good internal drainage. On May 11 balsam fir seed was broadcast at the rate of about 8,000 viable seeds per acre (about 18,000 total seeds).

The first-year stand amounted to 1,133 trees per acre. However, a very heavy loss over winter and during the following spring left only 141 trees per acre. This number dwindled to 49 by the fall of 1949, when the seeding was accounted a failure. The final second-year count yielded a tree-percent value of less than 1 percent, based on number of viable seed sown.

Direct Seeding in Small Openings in Second-Growth Northern Hardwoods

In the fall of 1947 and spring of 1948 a direct seeding of balsam fir was made in a small opening (about one-fifth acre) in the second-growth northern hardwood type on the Argonne Experimental Forest. The purpose of this seeding was to test initial survival from fall versus spring sowing under screened and unscreened conditions. Fall seeding was done on Oct. 20, 1947. Spring seeding was done on April 22, 1948. One seed lot for the spring sowing was unstratified. The other was cold-soaked from April 5 to April 13 and then held in moist cold storage at 32° F. until sown. Seed spots were prepared by raking off the leaf litter on a spot about 12 inches in diameter. Quite a few spots fell in or near skid trails left from fall 1947 logging. Seed was covered with mineral soil and pressed down by hand. Samples of the seed used had shown a germination of 46 percent in 45 days, after stratification for 45 days in moist sand at 40° F.

Germination more prompt in fall seeding.--Seven counts were made during the first summer and fall on a sample of the seed spots to obtain an idea of the promptness and completeness of the germination by sowing periods and seed treatment. There was a much more prompt germination by fall seeding compared with spring seeding and a slight advantage in screened over unscreened spots (table 6). Of the seedlings present in the spring of 1949, some 5.2 percent were new seedlings that were delayed germinators.

Water soaking and cold moist storage showed a mid-season and late-season advantage in stand (Lot A versus B). The germination (in this case also tree percent) in the range of 8 to 15 percent is considered unusually good for field seedings, especially since the lot of seed used had a laboratory germination of 46 percent.

Screening beneficial.--More comprehensive counts on all the staked seed spots over a period of 11 years (table 7) revealed that the screens which had been left on until fall of the second year, had a considerable protective effect. They not only kept the rodents and birds excluded but also reduced the amount of first-year overwinter loss due to leaf smothering. At the end of the first year seedlings are usually in the range of ½ to 1 inch high and thus are highly susceptible to smothering by the leaves of hardwoods and of brush such as raspberry. In the spring-seeded areas, the overwinter loss in stand was 12 and 52 percent respectively for screened versus unscreened. The 40-percent difference is practically all due to smothering by leaves and toppled weeds, which also tend to mat down the delicate first-year coniferous seedlings. For the fall-seeded trees, which germinated earlier and hence were slightly taller and more stiff-stemmed and sturdy, the overwinter losses were 13 and 30 percent respectively for screened versus unscreened, or a difference of 17 percent attributable largely to leaf smothering.

Table 6.--First-year germination on direct-seeded balsam fir in a small opening in second-growth northern hardwoods

(In percent)

Date counted, 1948	Fall sown		Spring sown		
	Screened	Unscreened	Screened	Unscreened	
				Lot A[1]	Lot B
June 10	9.5	5.0	2.0	1.0	1.0
17	11.0	7.0	3.5	1.0	3.0
25	12.0	9.0	4.5	4.0	3.0
July 1	14.0	11.5	5.0	6.0	4.5
13	16.0	13.5	5.5	10.5	6.5
20	16.5	15.0	7.5	11.0	7.5
Oct. 1	15.0	13.0	12.5	12.0	8.0
Percent of spots stocked on Oct. 1	90	80	90	70	70

[1] All fall-sown seed and spring-sown Lot B were untreated. Spring-sown Lot A and the screened spring-sown lot were pretreated by cold soaking and cold moist storage. Data are based on 10 seed spots with 20 seeds in each spot for each of 5 treatments, or a total of 1,000 counted seeds. Multiplying the values by factor 2.17 gives tree percent on the basis of viable seed sown as determined in a laboratory test.

Table 7.--Results of direct seeding in a small opening in a second-growth northern hardwood stand 1/

Date of count	Year	Tree percent				Percent of spots occupied			
		Fall seeded		Spring seeded		Fall seeded		Spring seeded	
		Screened	Unscreened	Screened	Unscreened	Screened	Unscreened	Screened	Unscreened
Oct. 1, 1948	1	12.5	8.0	16.5	9.5	88	68	90	80
May 23, 1949	1	10.9	5.6	14.6	4.6	78	52	80	48
Sept. 28, 1949	2	9.1	5.2	12.0	3.6	72	48	66	44
Aug. 23, 1950	3	5.5	2.0	8.5	2.0	48	24	58	26
Sept. 19, 1951	4	2.0	1.2	4.2	.6	32	16	32	8
Oct. 3, 1958	11	1.5	1.0	2.5	.0	22	16	24	0

1/ Based on 50 seed spots with 20 counted seeds per spot for each of four treatments, or a total of 200 spots involving 4,000 seeds. Tree percent refers to relation of surviving trees to total number of seeds sown.

At the end of 11 years, stocking was poor in screened and a near failure in the unscreened spots. The height of surviving trees at the end of the 11th year averaged only 0.6 foot for screened and unscreened trees.

The hardwood overstory has now closed over the 1/5-acre opening, and survival of the seeded fir is extremely doubtful.

Planting Results

Planting in Sodded Understocked Second-Growth Northern Hardwoods

In the spring of 1948 an area of understocked northern hardwoods with a basal area about 5 square feet per acre located on the Argonne Experimental Forest was disked and planted on May 6 to 8, using balsam fir and white spruce transplant stock. The area had been in rather heavy to medium sod, it being densest in open areas. The tract was quite level and the soil a silt loam to loam of good moisture relations and of good internal drainage.

Balsam fir developed very slowly during the first 4 years. It tended to be somewhat off-color. After the fourth year the fir had a considerably better appearance, but its annual growth was still less than that of white spruce (table 8). In the second growing season (1949) both species were set back by late spring frost injury (accentuated by flat terrain), especially the balsam fir trees of which only 7 percent of the trees were rated as thrifty in appearance and vigor, compared to 26 percent of the spruce.

Table 8.--Survival and height of transplants of balsam fir and white spruce planted in understocked sodded second-growth northern hardwoods

Years in field	2-2 balsam fir		2-3 white spruce	
	Survival	Height	Survival	Height
	Percent	Feet	Percent	Feet
1	92	0.4	98	0.6
2	80	.4	97	.7
3	80	--	96	--
4	69	1.1	93	1.4
11	65	4.5	84	5.7

Measurements taken at the end of the 11th growing season still showed considerable superiority for spruce in terms of tree survival--84 percent compared to 65 percent for balsam fir. Average height growth was 4.5 feet for balsam fir and 5.7 feet for white spruce.

However, measurements of the terminal growth for the 11th season show greater height growth for the balsam fir. Unfortunately, this planting is located in an area with a high population of white-tailed deer, and the terminal shoots on the balsam are suffering from severe deer browsing (fig. 2). This has resulted in considerable growth loss during the fall and winter seasons. With a reduction of the deer population in this area, the balsam fir would probably outgrow the white spruce. Also, as the balsam grow beyond the reach of the deer, height growth should show a marked increase.

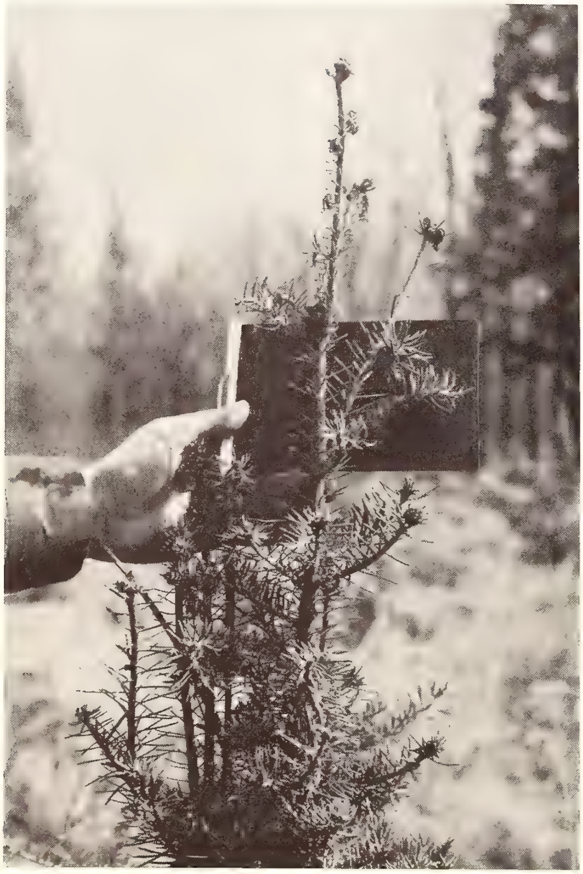


Figure 2.--Deer browsing on 11-year-old balsam fir has resulted in multiple leaders. This was 2-2 stock planted in the spring of 1948.

Planting of 4-0 Balsam Fir Under Thinly Stocked Second-Growth Northern Hardwoods

A 2.5-acre planting of 4-0 balsam fir was made on June 2 and 3, 1953, on a sandy loam soil in a stand of scattered second-growth hardwoods on the Argonne Experimental Forest. Where timber was present, the stand ranged from 20 to 40 square feet of basal area. About half of the area was open and heavily sodded. The tract had been thoroughly disked in the fall of 1952.

Survival at the end of 5 years, based on 100 staked trees was 88 percent. Average height of the trees was 1.5 feet. Browsing damage (the area has a high deer population) was found on 51 percent of the surviving trees.

The most interesting feature of this planting is the fact that 4-0 seedling stock gave high survival. The stock had grown at a density of around 10 to 15 trees per square foot in the nursery and had been rather heavily fertilized with leaf mold and complete commercial fertilizers. A top dressing of complete commercial fertilizer was also used in the spring of the third year. The stock was quite thick-stemmed and sturdy and was approximately equal in general size and development to the 2-2 stock mentioned elsewhere in this report.

The good survival obtained may provide a clue to somewhat cheaper production of nursery stock by use of 4-0 seedlings, grown at low-density and high-fertility levels, rather than standard 2-2 transplants.

Trials of seeding in mineral soils on subirrigated swamp margins

In the fall of 1947 and the spring of 1948 a seeding was made on sandy loam soil on the edge of a black spruce swamp on the Argonne Experimental Forest. The tract had a thin stand of black spruce, white spruce, hemlock, red and white pines, and a few small balsam fir. The ground cover was moderately dense blueberry, with some sweetfern, bracken fern, and thin raspberry. Some spots had moderately tough sod. It is the type of site on which balsam fir is often found growing naturally and where it appears to thrive. The water table in the spring of the year was close enough to the surface to be of some benefit to the seedlings.

The purpose of the test was to compare fall versus spring seeding and to determine the benefits of screening some of the spots. Fall seeding was done Oct. 20, 1947, and spring seeding on April 22, 1948. Twenty counted seeds were used per scalped seed spot. There were 100 seed spots in each of 4 treatment methods, or 400 seed spots total, involving 8,000 seeds. No aftercare such as weeding was done. Screens were removed during the second growing season.

Effects of Screening

Counts made over a period of 10 years show a fair initial stand of seedlings (table 9). The most striking feature was the very much better germination and stocking in screened over unscreened spots. In the fall seeding, the first-year stand showed 13 times as many seedlings in favor of screening. In the spring seeding there were three times as many seedlings in favor of screening. The fall seeding made the better showing because of the period of about 7 months (November to May) during which the ungerminated seed in the unscreened spots was subject to depredation by rodents and, to a lesser extent, by birds.

Only in the screened spots was there a reasonably satisfactory stand in terms of actual tree percent and spots occupied by seedlings, particularly for fall seedings. Where both lots were screened, the fall seeding had a moderate initial advantage over spring seeding, and this advantage had increased substantially by the end of the 10-year period. Unstratified seed was used in the spring seeding, and as a consequence some of the seed lay on the ground a full year before germinating.

The screens, removed in the summer of the second year, had afforded about 1½ years of protection. Judging from the percentage of overwinter reduction in the fall-seeded stand in screened versus unscreened spots (10 percent versus 38 percent), there was a moderate amount of overwinter loss by leaf smothering and by lodging of other vegetation such as bracken fern.

Losses after the third season were rather minor considering the seeding as a whole. This comparatively favorable evaluation can be attributed to the lack of a rank, dense overtopping type of vegetation such as was found on some other sites. This type of vegetation tends to lodge and mat down the seedlings or kill them from excessive shade. The shallow water table was, no doubt, a factor in providing supplemental moisture and reducing heat losses as has been pointed out in other studies (Stoeckeler and Limstrom, 1948).

Height Growth

The seedlings at the end of the fourth year were vigorous and had an average height of 0.3 foot; at the end of the 10th year they averaged 0.8 foot in height.

Table 9.--Results of direct seeding in a sandy loam soil on a swamp margin; seeded in fall 1947 and spring 1948

Date counted	Years of growth	Tree percent[1/]				Percent of spots occupied			
		Fall seeded		Spring seeded		Fall seeded		Spring seeded	
		Screened	Unscreened	Screened	Unscreened	Screened	Unscreened	Screened	Unscreened
Oct. 4, 1948	1	17.3	1.3	11.3	3.8	82	25	72	36
May 24, 1949	1	15.5	.8	[2/] 14.7	[2/] 4.6	82	12	[2/] 80	[2/] 46
Sept. 23, 1949	2	14.4	.7	9.5	2.9	80	12	70	33
Aug. 22, 1950	3	13.9	.6	7.3	2.4	80	10	60	26
Sept. 19, 1951	4	12.6	.5	6.7	2.1	76	8	52	24
Oct. 7, 1952	5	12.3	.5	6.2	1.9	74	8	46	24
Nov. 17, 1953	6	12.0	.5	5.7	1.2	74	6	46	16
Sept. 13, 1957	10	10.7	.3	4.5	.9	70	4	40	10

[1/] Values for tree percent on the basis of viable seed sown can be computed by multiplying all values by the factor 2.17.

[2/] Includes some trees which failed to germinate in 1948.

Trials of seeding in swamps

On Oct. 20, 1947, direct seeding was attempted in sphagnum moss on the edge of a swamp. The peat ranged from ½ to 2 feet deep. The overstory was a medium-density stand of black spruce poles from 3 to 7 inches in diameter. One hundred screened and 100 unscreened seed spots each received 20 seeds (4,000 seeds altogether) pushed down on a spot where the moss had been pressed down lightly with the ball of the foot. A thin cover of sphagnum was placed on top of each seeded spot.

Five counts were made over a period of 5 years. There was a striking first-year difference in favor of screening, the tree percents being 17.2 versus 3.9, or a ratio of 4.4 to 1. In terms of stocked spots, the percentage of stocking was 82 versus 36, or a ratio of 2.3 to 1 in favor of screening. In spite of a rather good initial stand of trees in screened areas, the stocking dwindled steadily until at the end of the fifth year it was only 14 percent compared to the initial stocking of 82 percent. In the fourth-year count many of the trees were drowned out by high water or were smothered by a dense growth of moss up to 6 or 8 inches deep, which had overtopped the balsam seedlings. There was survival only in the higher locations. In the fifth year the balsam fir was rated as in poor vigor, and off-color and yellowish in foliage, reflecting poor aeration and excessive wetness. The result was a failure even in screened spots due to the 87- to 92-percent loss of stand from May 1949 until October 1952.

Summary and conclusions

1. The results of a number of direct seedings and plantings of balsam fir are reported. Comparisons are made in a number of instances with planted white spruce.

2. Direct seeding was reasonably successful on (a) subirrigated sandy loam soils on the edge of peat swamps with ground prepared by scalping, and in (b) sapling and pole-sized aspen in the range of 2 to 6 inches in diameter where the ground was disked in strips and the protective overstory amounted to around 15 to 20 square feet of basal area.

3. Direct seedings of balsam gave poor results in (a) small openings in second-growth hardwoods prepared by scalping, (b) cross-disked, open, sodded land with only about 5 square feet or less of basal area of residual overstory aspen per acre, and (c) furrows in poorly stocked saplings of northern hardwoods.

4. Direct seedings of balsam fir were a failure in (a) open, sodded, disked, former hardwood land, (b) sphagnum moss on the edge of a peat swamp, (c) furrowed land in open sod, and (d) cross-disked, thinly stocked, sodded, second-growth northern hardwoods.

5. Screened spots invariably gave a much higher tree percent and percent of stocked spots than unscreened spots. The losses in unscreened spots were attributed largely to seed-eating rodents. The need for control measures to reduce population of rodents, particularly mice, is indicated if balsam seeding is attempted on a larger scale.

6. Shade of aspen or hardwood from an overstory of 15 to 40 square feet of basal area per acre increased survival of direct seeded balsam fir, but resulted in poorer height growth.

7. Disking, as a means of ground preparation, gave distinctly better stands in direct seeding than did furrowing.

8. The advantage of careful covering of the seed by hand was not clear-cut in terms of ultimate stand and stocking attained. The considerable increase in cost makes it doubtful whether it is worth covering the seed providing it can be dropped in favorable spots in newly prepared disked land. Brush dragging as a means of seed covering was poorer than no covering.

9. The use of cover crops to protect tender balsam seedlings from temperature extremes was unsatisfactory. Although a cover crop of rye gave some first-year advantage, this advantage was insignificant in terms of ultimate stand development.

10. In overall summation, the results reported here indicate that prospects of success with direct seeding of balsam fir are rather poor. Fair stands were established on a few limited sites either with moderate overhead cover of aspen-birch or scattered northern hardwoods or with shallow water tables. The risk involved, however, in direct seeding on these sites, indicates that in most cases a program of planting is preferable.

11. Plantings of 2-2 and 4-0 balsam fir were all successful, often through the 11th year. However, white spruce planted on comparable sites showed an advantage in survival over the balsam fir and greater height at the end of the 11th year. Balsam fir is apparently a very slow starter in its establishment and often requires 3 to 4 years before it begins to make reasonably acceptable annual height growth. In addition, height growth of balsam fir was reduced due to severe browsing by white-tailed deer.

Spruce made adequate growth after the first or second year in the field plantings.

12. Balsam fir seems, at present, to offer limited possibilities for reforestation by planting. Spruce will grow on practically any site adapted to balsam fir, and since the former has outstanding advantages over balsam fir, virtually all forest managers and industries would prefer the spruce over balsam.

13. However, the balsam fir planting and seeding results suggest the possibility of planting this species in 1- to 3-row parallel strips at intervals of about 100 feet in extensive areas of pure aspen or aspen-paper birch type growing on medium to good sites; the purpose of this would be to establish rows of seed trees to aid in natural reseeding, gradually getting a partial conversion to conifers and increasing the overall softwood supply.

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